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Sustaining and Improving Structured Simulation-Based Training

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The U. S. Army Simulation, Training, and Instrumentation Command (STRICOM) is developing the Close Combat Tactical Trainer (CCTT) to support maneuver training for platoon and company units. The CCTT is the first part of the Combined Arms Tactical Training (CATT) system providing operational training for combined arms forces on a virtual battlefield. The U. S. Army Research Institute (ARI) also is developing structured CCTT training support packages (TSPs) for required mission and task training. Successful structured training in the Virtual Training Program (VTP) with Simulation Networking (SIMNET) established a model for similar CCTT training. This report examines integrated system management needed to implement successful training with the CCTT and its TSPs. While CCTT development has focused on simulation requirements, and TSP development has focused on training requirements, total system management has been a secondary consideration. Conceived in a Total Quality Management (TQM) framework, the report proposes processes designed to sustain and improve the training effectiveness of the CCTT throughout system life. The emphasis is on continuous monitoring of training processes and products to provide management feedback, and establishing process action teams to define and solve system problems. The report identifies some training process indicators, and possible management support tools.

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Research Report 1722

Sustaining and Improving Structured Simulation-Based Training

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Training Systems and Education

FOREWORD

The U.S. Army Research Institute (ARI) Armored Forces Research Unit at Fort Knox is responsible for research and development on armor training and simulation. In conjunction with the Simulation Training and Instrumentation Command Project Manager (PM) for the Combined Arms Tactical Trainer (CATT) and the Training and Doctrine Command Systems Manager (TSM) for CATT, ARI contracted to develop structured exercises and training support packages for use in the Initial Operational Test and Evaluation (IOTE) of the Close Combat Tactical Trainer (CCTT). The CCTT is the first system developed as part of the CATT family of unit trainers. The CCTT system provides a simulated environment for training armor, armored cavalry, mechanized and infantry units. During a Limited User Test (LUT) of CCTT at Fort Hood, TX in preparation for the IOTE, ARI and the contractor monitored the initial trial implementation to formatively evaluate the developed exercises and training support packages.

ARI conducted this research pursuant to a Memorandum of Agreement with the U.S. Army Armor Center and Fort Knox: Manpower, Personnel and Training Research, Development, Test, and Evaluation for the Mounted Forces, 18 October 1995. The ARI Armored Forces Research Unit performed this research as part of Research Task 2124: Strategies for Training and Assessing Armor Commander's Performance with Devices and Simulations (STRONGARM).

The present research report identifies management procedures and tools needed to maintain and increase the effectiveness and efficiency of structured training with the CCTT. The report based its findings on observations during the LUT and previous experience with the Virtual Training Program using the Simulation Networking (SIMNET) system at Fort Knox with similar structured training exercises and support packages. The authors provided the information in this report to the PM-CATT and TSM-CATT, and presented its findings to the 1997 Fall Simulation Interoperability Workshop in Orlando, FL. This workshop series sponsored by the Simulation Interoperability Standards Organization develops standards and practices supporting the interoperability and reuse of models and simulations. The report will be useful to simulation and training system developers, training simulation managers, and others implementing structured training programs.

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SUSTAINING AND IMPROVING STRUCTURED SIMULATION-BASED TRAINING

EXECUTIVE SUMMARY

Research Requirement:

The U.S. Army Research Institute (ARI) Armored Forces Research Unit at Fort Knox has developed a structured training methodology for exploiting the use of virtual (e.g., Simulation Networking--SIMNET) and constructive (e.g., Janus) simulations. Structured exercises and training support package (TSP) materials developed for the Virtual Training Program (VTP) at Fort Knox have proved to be effective, enabling efficient use of these simulations. This methodology was then applied to develop a limited set of similar structured exercises and TSP materials for the Close Combat Tactical Trainer (CCTT). The Combined Arms Tactical Trainer (CATT) program, directed by the U. S. Army Simulation, Training, and Instrumentation Command Project Manager (PM-CATT), is developing CCTT as the first system in a family of simulations designed to meet established unit collective training requirements. The CCTT and CATT are central elements of the Combined Arms Training Strategy that emphasizes simulation training as a key to maximizing the benefits of limited unit field training resources. Simulation training prepares units for field training as well as helping to sustain unit proficiency after field training. The Initial Operational Test & Evaluation of the CCTT will examine system training effectiveness using the structured training exercises and TSP materials developed by ARI, and reviewed and approved by the Training and Doctrine Command System Manager (TSM-CATT). Research on management and delivery of structured training contributes to the long-term effectiveness of the CCTT training program as implemented by Army units.

Procedure:

ARI and contractor personnel monitored the initial trial implementation of the developed exercises and TSP materials during the CCTT Limited User Test (LUT). The Test and Experimentation Command (TEXCOM) conducted this test at Fort Hood, TX to plan and prepare for the IOT&E. Observed problems were noted and discussed with site Contractor Logistical Support (CLS) personnel, unit trainers and leaders, TEXCOM observers, and representatives of the PM-CATT and TSM-CATT. The contractor obtained comments that raised additional issues from interviews and surveys conducted as part of the formative evaluation of the TSPs conducted in conjunction with the LUT. ARI selectively reviewed published literature on quality management methods, and interviewed points of contact provided by the Fort Knox Office of Total Army Quality.

Findings:

Management and execution of structured training with the CCTT presents a number of significant challenges. In part, the system design engenders these challenges by controlling an

exercise through operation of a number of interacting workstations. Furthermore, unlike the VTP with SIMNET and Janus, there is no established group of observer/controllers dedicated to operator duties and supervising training. Manning the workstations takes a combination of CLS personnel provided by the CCTT site, and Army trainers and operators provided by the training unit's superior headquarters or sister units. The Army personnel require considerable preparatory training and rehearsal to perform their roles properly in structured training exercises.

Several other threats to the effectiveness of CCTT include: (a) divided administrative responsibilities requiring coordination among the installation, CCTT site, and training unit, (b) competing demands on Army personnel making it difficult to provide qualified trainers and operators with sufficient time for preparation, (c) complex procedures for preparation and training leading to incomplete or imperfect execution, (d) long lead times required for any substantial exercise modifications desired by units, (e) systems limitations and effort required to modify exercises required by CCTT changes in hardware and software, and (f) unmet needs for new exercise development associated with long-term changes in Army equipment and doctrine (e. g., digital operations).

Conceived in a Total Quality Management (TQM) framework, this report proposes processes designed to sustain and improve the training effectiveness of the CCTT throughout system life. The emphasis is on continuous monitoring of training process and product indicators to provide management feedback, and establishing process action teams to identify and solve system problems. The Army has adopted TQM as part of its management philosophy, and has established a Total Army Quality (TAQ) program with offices at most installations. However, the TAQ program has addressed few training issues. Installation commanders could employ some TAQ assets to foster continuous improvement in CCTT training. The report identifies some training quality indicators, and management support tools that should network and operate with both the CCTT and existing Army training management software and databases.

Utilization of Findings:

Installation commanders and site managers can use this report to improve management and implementation of CCTT structured training. The findings should prove to be generally useful to developers of simulator systems, and developers of structured exercises and TSPs for simulator training programs. The information in this report should contribute to interoperability standards for the simulation Federation Development Process. The report also suggests standards for training management tools required in future simulations that conform to the High Level Architecture mandated by the Defense Modeling and Simulation Office.

SUSTAINING AND IMPROVING STRUCTURED SIMULATION-BASED TRAINING

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Introduction

The Close Combat Tactical Trainer (CCTT) being developed by the U. S. Army Simulation, Training, and Instrumentation Command (STRICOM) will support maneuver training for fully-manned platoon and company units. The CCTT also will support battalion task force exercises, with leaders in manned simulators controlling attached semi-automated force (SAF) vehicles that fill out their units. The CCTT is the first part of the Combined Arms Tactical Trainer (CATT) system providing operational training for total combined arms forces on a virtual battlefield. The U. S. Army Research Institute (ARI) is developing structured training support packages (TSPs) for required mission and task training using the CCTT. Successful demonstration of structured training in the Virtual Training Program (VTP) with Simulation Networking (SIMNET) established a model (Burnside, Leppert, & Myers, 1996) for similar CCTT training.

This report examines needs for integrated system management to successfully implement the CCTT and its TSPs. While CCTT development has focused on meeting simulation requirements, and TSP development has focused on training requirements, total system management has been a secondary consideration. Conceived in a Total Quality Management (TQM) framework, this report proposes processes to help sustain and improve the training effectiveness of the CCTT throughout system life. The emphasis is on providing management feedback by continuously monitoring training process and product indicators, and on establishing process action teams to identify and solve system problems.

After development by STRICOM, the fielded CCTT will support Active Component units with company sets at fixed sites, and will support Reserve Component units with mobile platoon sets. Contractor logistic support (CLS) staff will maintain and operate the CCTT system. CCTT development did not include the structured training program as an integral part of the system, and it did not influence system design. Thus, the current CLS contract does not explicitly charter nor fully resource administration and implementation of this training program. Management of the total CCTT training system necessarily involves shared responsibility and coordinated action among the training units, the CLS contractor, and the installation hosting the units and the CCTT system. Allocation of training duties and responsibilities were considered in the design of CCTT structured training. Additional oversight and feedback mechanisms would assure that all follow recommended procedures, and help to sustain and improve the quality of training. The Total Army Quality program suggests mechanisms needed to establish an effective framework for managing structured training programs.

Army experience with CCTT structured training and its predecessor VTP program should influence future simulation standards. The approved recommended practice standard for distributed interactive simulation (DIS) (Institute of Electrical and Electronics Engineers, 1996) only treated exercise management and feedback concerns in relation to single exercises. This standard failed to consider needs associated with long term use of a simulation system with a standard library of training exercises. The CCTT is a DIS system in part, but also is compliant with standards for the High Level Architecture (HLA) introduced to promote simulation interoperability and software reuse (Under Secretary of Defense for Acquisition and Technology, 1995). As in the DIS standard, long-term management of training programs is an issue neglected in the HLA federation development and execution process model (FEDEP) (Defense Modeling and Simulation Office, 1996). The FEDEP model is being revised and expanded in workshops conducted by the Simulation Interoperability Standards Organization (Bouwens, Freeman, Harkrider, & Zimmerman, 1997).

Structured Training

Structured training provides mission-based and task-focused exercises for units or staff groups. Deliberately designed in the exercises are specific situations and events that assure appropriate conditions occur for practicing performance of particular tasks, sub-tasks, or actions. Structured training derives from and implements the Systems Approach to Training (SAT) prescribed by regulation (U. S. Army Training and Doctrine Command, 1995; Brown, 1993). Structured training may be developed for live, virtual, or constructive environments.

Fundamental Precepts

The VTP developed structured training exercises designed to exploit capabilities of the SIMNET system for units, and Distributed Janus for staffs. The U. S. Army Research Institute Armored Forces Research Unit (ARI-AFRU), the U. S. Army Armor Center (USAARMC), and the Army National Guard (ARNG) jointly directed the VTP project. Initially, the design team adopted several training principles to guide the development (Campbell, Campbell, Sanders, & Flynn, 1995). These principles remain central to the structured approach for training small units. Later projects modified and expanded them for larger units and staffs (Campbell & Deter, 1997).

Scenario-Embedded. A logically sequenced scenario for a complete mission with realistic situations and conditions places exercises in meaningful operational context. This context should aid transfer of training.

Execution Focus. Practice emphasizes actions required to execute the mission. This makes best use of simulation capabilities and on-site time. The unit receives mission orders and map overlays in advance of scheduled exercises to enable it to conduct planning and preparation activities off-site.

Mission Segments. Exercise duration is limited by executing a phase of the total mission lasting one hour or less for platoons or companies. This allows frequent after action reviews (AARs) when memory for events remains fresh. The end of one phase is the starting point of the phase in the next exercise. Higher-level units or staffs may complete longer exercises with larger mission segments based on typical pauses in the mission sequence.

Task-Driven. The detailed arrangement of scenario events deliberately elicit and constrain execution of specific tasks that form the training objectives, thereby enabling observation and evaluation of performance based on task standards. The same task objectives set the framework for an AAR designed to provide carefully structured performance feedback.

Compressed Time. Trainers follow a set agenda to deliver as much training as possible in the available time. Preview, execution, and AAR activities total about two hours for platoon or company exercises. In execution, tasks follow each other in close sequence with minimal slack time, and with few events and actions unrelated to the training objectives. Efficient training is a priority for the VTP because of limited time available to ARNG and Reserve units.

Fully Supported. TSPs provide unit preparation guidance, and detailed event guides and other materials for observer/controllers (O/Cs) and simulator operators who conduct and assist the training. These trainers provide "turn-key" operation of the simulation and training system. Unit personnel cannot be expected to acquire technical knowledge of system capabilities and operations to the degree necessary for effective simulation-based training. Commanders and staffs also should not expend precious time repeatedly creating exercises that "reinvent the wheel" before training their units in simulators.

Standardized Library. A sufficient number of TSPs are made available to support repeated practice of basic skills needed to execute common tasks in the Mission Essential Task List (METL) for a particular type of unit. The library provides gradually increasing levels of difficulty, and unit progression in the sequence should be performance-based. After mastering basic skills with standard TSPs, new exercise variations and new missions can provide additional challenges.

Previous Developments

The VTP project (Hoffman, Graves, Koger, Flynn, & Sever, 1995) created a training library based on two missions for mechanized infantry and tank units with over 100 structured platoon, company, battalion, and battalion staff-level exercises. This library also included exercises for scout platoons and cavalry troops. Shlechter, Bessemer, Nesselroade, & Anthony (1995) report evidence for training effectiveness obtained during initial exercise trials. Strong evidence for program success is the increased demand for VTP training over several years as shown in Table 1 (Russell, 1996). After focusing on platoon-level training in the early years of the VTP, training at the more advanced company-level increased in 1997.

Table 1

Number of Units Served Yearly by the VTP

	Year			
Unit Level	FY 94	FY 95	FY 96	FY 97 [1]
Platoon	107	265	367	169
Company	23	55	41	121
Battalion	14	28	36	13

[1] Numbers provided by the Armored Warfighting Training Directorate O/C Team.

Follow-up questionnaires and interviews with departing members of the initial VTP O/C team (Shlechter, Kraemer, Bessemer, & Burnside, 1996) showed high consensus that VTP training substantially improved the tactical performance of both leaders and units. The O/Cs observed that leaders gained in command and control skills, situational awareness, and apparent self-confidence. Units gained in reporting, actions on contact, formation execution, teamwork, and cohesive action. However, The O/Cs pointed out several aspects of the materials and procedures that needed fine-tuning. The O/Cs also noted that units require better advance preparation before their VTP training.

Subsequent projects using the same structured approach have expanded the VTP to brigade staffs (Koger, Long, Britt, Sanders, Broadwater & Brewer, 1996), a third mission (Graves & Myers, 1997), and leaders of combat support (CS) and combat service support (CSS) platoons (Hoffman, in press). BDM Federal led the contractor team, with Human Resources Research Organization (HumRRO) and Litton-PRC, to develop the original VTP and later expansions, monitored by ARI-AFRU.

Another recent project developed structured brigade staff exercises using the Brigade/Battalion Simulation (BBS) (Graves, Campbell, & Deter, in press). This project also developed brigade staff section exercises for "live" tactical operations centers (TOCs), and for BBS and Janus environments. For this work, HumRRO led the contractor team, with BDM Federal, Hughes Training, and Litton-PRC, and monitored by ARI-AFRU. Campbell, Deter, & Quinkert (1997) describe the extension of the development methodology for structured training to brigade level.

CCTT Structured Training

A contractor team developed an initial limited set of 40 structured TSPs for the CCTT (STRUCCTT Team, 1997). Senior Army personnel selected the exercises in this set to parallel some of those available in the VTP for tank and mechanized infantry platoons and company teams performing three missions: movement to contact, deliberate attack, and defense in sector. Besides the initial TSPs, the team designed complete exercise libraries for these types of units and missions. In addition, the team did one battalion task force TSP for a movement to contact mission. The Operational Test & Evaluation Command (OPTEC) funded the CCTT TSP development to support acquisition testing and evaluation of the CCTT system. The contract titled "Structured Training for Units in the Close Combat Tactical Trainer" (STRUCCTT) was monitored by ARI-AFRU. HumRRO led the contractor team with BDM Federal, Hughes Training, and Litton-PRC. A follow-on effort is developing exercises for the heavy cavalry troop and scout platoon, and a task force exercise for a defense in sector mission. Work has also begun to design a training program and TSPs for the tactics, techniques, and procedures (TTP) employed in digital operations with M1A2 tanks and M2A3 infantry vehicles.

New CCTT simulation capabilities unavailable in SIMNET substantially enhance the CCTT TSPs compared to their VTP counterparts. For example, CCTT allows variation in visibility conditions. Advanced Semi-Automated Forces (SAF), CS, and CSS workstations, and dismounted infantry squad stations operated by squad leaders provide many more capabilities. The CCTT TSPs include as many new conditions as possible in at least one exercise to enable comprehensive testing. The TSP content and techniques have been reviewed by the Armor and

Infantry Schools and approved by the Training and Doctrine Command (TRADOC) System Manager for CATT (TSM-CATT).

In 1997, first use of the TSPs occurred during CCTT system integration testing and a pilot test. After adjustments for CCTT software changes, the STRUCCT team completed a formative evaluation of the TSPs during a Limited User Test (LUT) at Fort Hood, TX. The refined TSPs are now being used in the CCTT Initial Operational Test & Evaluation in 1998.

Army Management

Serious efforts to spread the philosophy and methods of Total Quality Management (TQM) throughout the federal government began by establishing the Federal Quality Institute in 1988. By 1992, over 2/3 of federal agencies surveyed reported using TQM in some way (Shoop, 1993). In that same year, the U. S. Army formally adopted TQM as part of its management philosophy (Department of the Army, 1992). Under the banner of "Total Army Quality" (TAQ), offices opened at all major commands and installations. The TAQ offices train Army leaders and the military and civilian workforce, giving them both concepts and tools needed to change Army management practices. To quote General Sullivan (Office of Total Army Quality, 1996), who was Army Chief of Staff in 1992, "The implementation of the Army's Total Army Quality philosophy is not optional." However, he went on to state that leaders must tailor TAQ to fit their own organizations. The TAQ approach has been largely non-prescriptive, encouraging demonstration projects to improve processes and results.

Performance Improvement Criteria

As an inducement to implement TAQ management, the Army conducts a competition with winning installations receiving substantial monetary awards. Organizations submit entries describing practices in six areas corresponding to the Malcolm Baldrige categories in civilian TQM competition, plus one category added by the Army (Office of the Army Chief of Staff, 1997):

- Leadership
- Strategic Planning
- Customer and Market Focus
- Information and Analysis (added category)
- Human Resource Development and Management
- Process Management
- Business Results

The seven categories subsume 20 items, with detailed criteria for each item. Only the Human Resource Development and Management category relates to training. It includes criteria for employee education, training, and development in general terms, but does not address soldier skills or training for combat. The imperative to apply TAQ to military training is an inference from unit missions.

TAQ Infrastructure

In a nutshell, the Army's management philosophy is to "Do the right things, the right way, for the right reasons, and constantly strive for improvement" (Department of the Army, 1992). One key to this philosophy is leadership as the first Baldrige category suggests. For success, TQM requires managers to have constancy of purpose, shared strategic vision, deployment of that vision in goals and action plans, determination to provide the necessary resources, and willingness to fully empower subordinates to develop and adopt process changes. The senior commander and subordinates must be entirely committed to quality improvement principles and the worth of the effort required. Leader involvement in working groups organized to direct or execute TAQ projects reflects this commitment.

As one example, Fort Knox established a three-tiered system of TAQ working groups: an Executive Steering Committee (ESC), three Quality Workforce Boards (QWBs), and Process Action Teams (PATs) as needed for specific projects (Office of Total Army Quality, 1996). The ESC, composed of senior leaders, is responsible for TAQ policy, developing the USAARMC vision, setting goals and priorities, directing actions, and monitoring progress. QWBs include organizational leaders responsible for TAQ actions in the areas of base operations, training, and futures. The QWBs identify processes in their assigned areas, set action priorities, and establish PATs for specific projects. QWBs then review results, and approve and lead changes in their organizations.

PATs apply TAQ methods to selected work processes in the scope of their charters. They identify and solve problems, and implement effective changes. PATs are cross-functional with members assigned as needed to work on a project. A PAT will include representatives of "owners" (organization leaders) of chosen work processes, expert personnel directly involved and in these processes, experts on related processes (delegated by suppliers or customers that interact with the primary organization). The PAT also may include technical advisors or consultants for specific issues or methods. A facilitator, expert in TAQ methods, is assigned to train, coach, and assist the PAT, and uses team-building techniques to improve its work.

TAQ in Practice

The core TQM instrument of change and continuous improvement is a scientific problem-solving approach based on facts about both process and results. Instead of managing by results, quality leadership manages processes to produce results (Sholtes, 1988). This approach employs the Plan-Do-Check-Act (PDCA) or "Shewart" cycle described by Deming (1986) and Walton (1986). Continuous improvement results from cycle repetition. Sources often expand and elaborate The PDCA cycle in different ways, but the TAQ Office at Fort Knox (Office of Total Army Quality, 1996) teaches six steps:

- Define the Problem (Plan)
- Identify Possible Causes (Plan)
- Evaluate Possible Causes (Plan)
- Make a Change (Do)
- Test the Change (Check)
- Take Permanent Action (Act)

A PAT uses specific methods, techniques, and tools to perform each step (GOAL/QPC, 1988; Sholtes, 1988). To summarize briefly, the PAT carries out the Plan steps to develop a detailed understanding of a work process producing a product or delivering a service. This understanding includes the customer's criteria of quality (value) for the process output, the sequence of actions and decisions leading to the output, workforce roles, inputs to the process, and known problems. Based on the process description, the PAT defines performance measures, collects and analyzes data to examine the state of the process, and identifies or confirms problems. The PAT also speculates about cause-effect relations, and collects data to evaluate cause-effect hypotheses.

At the next step (Do), the PAT develops and tries out a process change on a limited scale. The effect of the change is measured (Check) to determine if the result meets expectations. The PAT may compare results before and after the change, or test the effect by formal controlled experiment. If results confirm the benefit of the change, the last step makes it permanent (Act).

The USAARMC has completed several successful TAQ projects, mainly related to processes in base operations. The Armor School formed just one PAT to address an issue directly related to training. This PAT sought to improve methods used to survey customer organizations about the quality of assigned course graduates. The Armor School did not fully test or implement planned changes in that case. Organizations that manage the VTP program or other simulation training have not conducted TAQ projects.

CCTT Training Management

In theory, U. S. Army units manage training in a repeated cycle: assessment of training needs, planning and scheduling, executing training, evaluation, and reassessment (Department of the Army, 1990). The structured training processes and the responsibilities assigned were designed to be compatible with this cycle. Structured training supports the general goals of using the CCTT to prepare for subsequent unit training in field exercises, and to sustain unit proficiency after field training. The processes also fit within the constraints imposed by the simulation equipment provided at CCTT facilities.

CCTT Components and Operation

A typical CCTT site will have two company sets of manned simulator modules, including 14 M1A1 or M1A2 Abrams tanks, and 14 M2A2 or M2A3 Bradley infantry fighting vehicles. Two dismounted infantry modules are available for use with the infantry vehicles. The site provides one M981 Fire Support Team Vehicle, as well as one M113 Armored Personnel Carrier and one High Mobility Multi-Purpose Wheeled Vehicle for various roles.

A Master Control Console (MCC) and five AAR workstations provide system initialization and control. The AAR stations independently can control several simultaneous exercises. Supporting these exercises, ten SAF workstations control Blue Force (BLUFOR) or Opposing Force (OPFOR) simulations of unmanned vehicles and units of many possible types, all operating in a tactically realistic manner. Eight Unit Support Workstations (USW) are available to simulate a number of CS and CSS functions:

- Mortar Fire Direction Center (FDC)
- Field Artillery Battalion TOC (FABTOC)
- Fire Support Element (FSE)
- Combat Engineer Support (CES)
- Tactical Air Control Party (TACP)
- Combat Trains Command Post (CTCP)
- Unit Maintenance Collection Point (UMCP)
- Higher Headquarters Support (HHS)

Full-time CLS staff operate the MCC, SAF, and AAR workstations. However, unlike the VTP in SIMNET, the CCTT by design has no dedicated full-time trainers. The CCTT device requirement specified operation without added Army personnel spaces (U. S. Army Training Support Center, 1998). To conduct training, the unit's higher command must assign one or more O/Cs and several USW operators (usually at least three), or the unit must recruit personnel from sister and supporting units. Sites also have personal computers with Interactive Courseware (ICW) programs that provide self-paced workstation operator training (also called EDUCATT).

CCTT Structured Training Process

Figure 1 presents an outline of the structured training process used with the CCTT. The pre- and post-exercise phases include CCTT-related activities done off-site before and after the unit trains at the CCTT site. On-site activities include some general preparations for CCTT operations, leading to unit training in one or more specific exercises. Each exercise has preview, execution, and AAR phases.

In the pre-exercise phase the unit commander and staff assess training needs and elect or receive direction to include the CCTT in their training plans. They contact the CCTT Site Manager who provides TSP materials and schedule information. After reviewing materials and selecting exercises, they schedule training, and can request exercise modifications. While the CLS operators can make some minor changes when an exercise is initialized, most substantial changes in initialization files must be made well in advance of the training date. Large modifications of the exercises also require revision of the TSP materials to make the O/C and USW operator guides consistent with the actual exercise situation. The unit staff must also coordinate and schedule O/Cs and USW operator support, schedule on-site ICW (EDUCATT) training for them, and distribute TSP guidance materials.

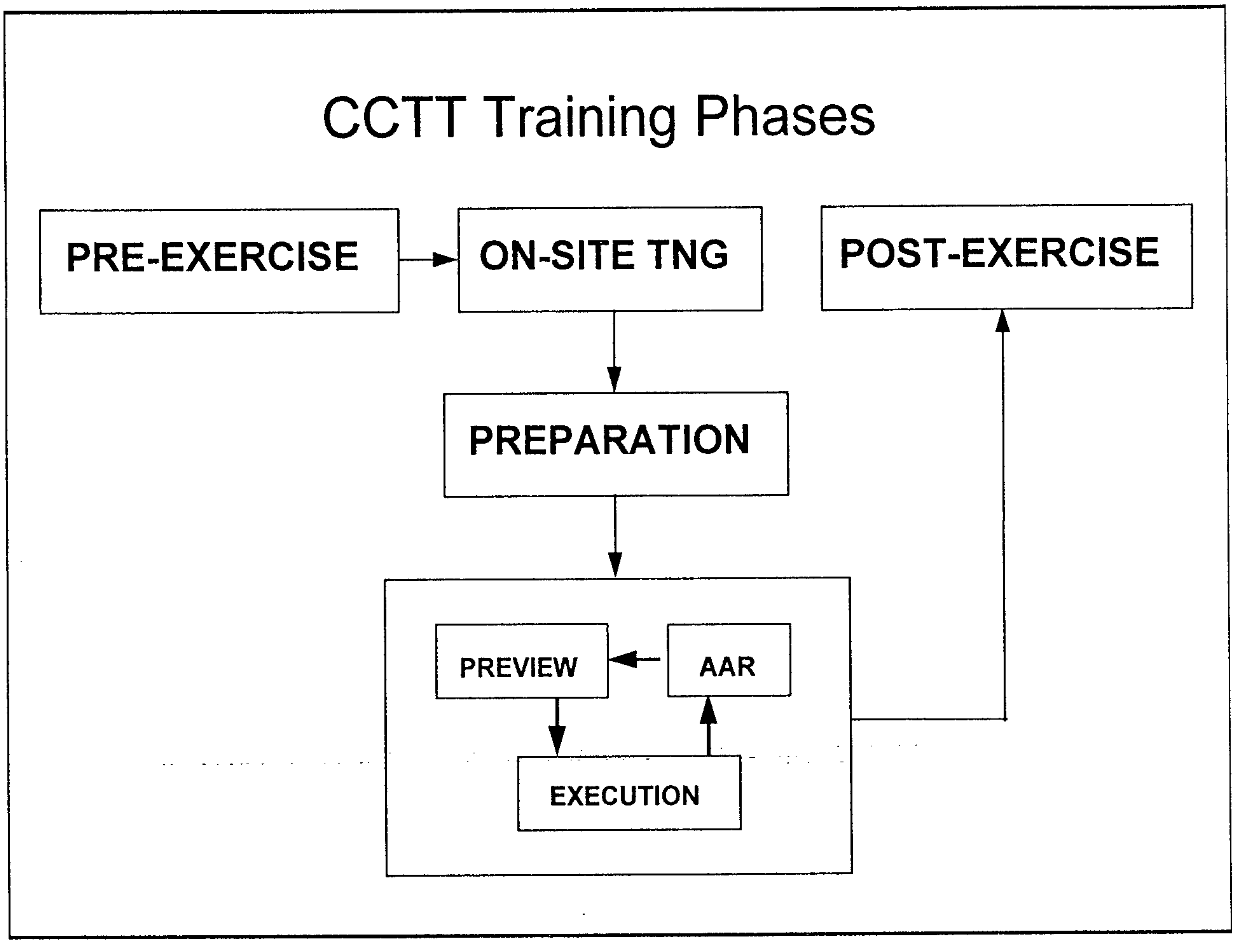

Figure 1. Phases of structured training process.

Near the training date, the unit commander and staff issue orders and map overlays for all planned exercises, conduct troop-leading procedures, and supervise unit rehearsals. The O/Cs and workstation operators must study their TSP exercise guidance materials, and participate in unit rehearsals. Meanwhile, the Site Manager assigns CLS operators and trains them when needed to maintain proficiency. The CLS operators review TSP guidance materials in advance for the scheduled exercises, and make requested changes in exercise files.

Preparation often begins during the week before the scheduled training. The O/Cs and USW operators visit the site to take the EDUCATT ICW training for their positions. CLS operators then conduct a workstation orientation exercise with the O/Cs and USW operators to apply and practice what they learned in ICW training. When the unit arrives for training, site staff conducts unit preparation activities, presenting an introductory briefing to provide an overview of CCTT training and site ground-rules, and leading a site tour showing the facility layout. Vehicle crews then participate in an orientation exercise enabling them to adjust to the operation of manned simulator module displays, controls, and communication equipment, and to navigation on simulated terrain. The exercise also provides experience with the visual appearance of vehicles, cultural features, and weapon effects represented in the CCTT simulation. Before each training exercise, CLS operators check the CCTT system, and activate appropriate initialization files.

Training exercises begin with a preview. The O/C summarizes the mission and situation in the context of higher-level orders, and reviews tasks that the unit will perform. The unit commander briefs back his intent, operations order, and plan for executing the mission. Crews then occupy their vehicle modules and conduct pre-operations checks. At the same time, the commander uses the terrain display at the AAR station, assisted by the AAR operator, to conduct a reconnaissance of the area of operation with his subordinate leaders.

During exercise execution, the O/C, AAR and SAF operators, and USW operators all follow a detailed event guide showing when to initiate various actions or communications. The event guide helps to create the tactical environment requiring performance of tasks trained in that exercise. At the AAR station, the O/C listens to radio transmissions and sends scripted messages to play the role of the superior commander and other elements with which the unit interacts on the radio. He regulates the timing of actions by the supporting SAF and USW operators, observes unit performance on the visual displays, and notes items for later reference in the AAR. The AAR operator positions the view of the battlefield so the O/C can observe from an advantageous point. SAF operators control the actions of OPFOR units and friendly BLUFOR units following O/C directions and the event guide. USW operators communicate with the O/C and unit as they would on an actual battlefield in that situation, and execute the CS and CSS functions called for by the event guide.

In the AAR, the O/C follows an outline focused on tasks performed in the exercise. He facilitates the unit's discussion of what happened, why it happened, and how to improve future performance. SAF and USW operators may participate to clarify events from their perspective. The O/C leads the unit to self-assess some aspects of performance that the unit should sustain or improve in the future. The AAR operator assists the O/C by replaying selected exercise segments, including radio traffic, showing important elements of performance for discussion.

After completing CCTT training, the O/C prepares a task-based Post-Exercise Report on unit performance. The unit commander reviews and distributes the report to his staff and other subordinates. Ideally, they all should use the report to reassess the unit's training status, and to update and revise training plans based on their assessment.

Threats to Effectiveness

The CCTT structured training process is rather complex. Several factors can degrade the effectiveness of the training delivered by the program. In the beginning, initial unfamiliarity, divided responsibilities, the lack of dedicated trainers, and time limitations may impede full implementation of the designed training process. The novelty of the CCTT and the structured TSPs, and the sheer bulk of the new guidance materials require repeated study to absorb all the details. The division of responsibility and coordination required among the installation command, units, and site makes it easy to overlook important steps or to leave them unfinished.

For example, if distribution of TSP materials is late, unit leaders, O/Cs, and USW operators may not have an opportunity to study the materials in detail. Furthermore, commanders may not identify exercise modifications that would better meet the unit's training needs, or may not be able to request changes with sufficient lead-time.

Without a cadre of dedicated trainers, the TSP developers initially can only train the CLS operators. These operators must then continually train new O/Cs and USW operators. The constant turnover of O/Cs and USW operators necessarily limit their mastery of the CCTT equipment and the guidance materials for the training exercises. Finally, units currently have full training calendars and many other obligations, and will find it difficult to allot much time to CCTT training. Advance troop leading procedures and unit rehearsals needed to prepare for training may be minimal or even omitted. Last minute preparation on-site may reduce the time used in CCTT training. Time also is limited for critical personnel to train and serve as O/Cs or USW operators. The result can be under-use of the CCTT, or delivery of poor training by trainers lacking sufficient preparation.

Long term, many of the initial CCTT problems may be reduced, but not entirely eliminated, as experience using the CCTT spreads, and units return for repeated training. However, other factors will remain in play throughout the life of the CCTT system. As technology advances, the CCTT will have frequent hardware and software upgrades. During earlier product integration testing, such changes often required revision of exercise initialization files and TSP materials. Similar revisions will be necessary as CCTT continues to expand and improve. The CCTT Training Device Requirement (U. S. Army Training Support Center, 1998) lists many preplanned product improvements in a variety of areas. Furthermore, as the Army moves toward digital operations, CCTT training will have to incorporate a constant flow of new doctrine, missions, METL tasks, and TTPs. To meet these new training needs, existing exercises will require modification and new exercises developed to expand the TSP library. Wilkinson (1997) suggested that intelligent software is needed to assist CCTT users in selecting, modifying, or creating new exercises, and such software now is being developed (U.S. Army Research Institute for the Behavioral and Social Sciences, 1997).

The challenges are to assure: (a) that the CCTT training process is implemented as designed, (b) that a high level of training effectiveness is maintained with consistency, and (c) that the total training system can adapt to a changing environment. To meet these goals while overcoming both short- and long-term potential problems, TQM mechanisms can provide the corrective actions and continuous improvement needed to maintain and strengthen the total CCTT system. With such a training system that is continually evolving, any short-term test or evaluation can only provide a snapshot assessment of its current state at one point in time. System managers must monitor and evaluate system processes and products continuously throughout its life cycle to sustain the expected return on the Army's investment.

Applying TAQ Methods To The CCTT

The specific procedures defined in the CCTT structured training process facilitate application of TAQ methods. TAQ management projects can therefore start from an established training process model. This model provides a baseline condition and point of departure for developing and evaluating changes.

Organizing for TAQ Management

To provide command emphasis and leadership for CCTT TAQ projects, the installation commander should establish a steering committee with the same functions as the Fort Knox ESC. Members should include the commander himself, senior leaders or representatives of major local commands and any other organizations that relate to CCTT operation and training, the CCTT Site Manager, and the head of the local TAQ office. Members also should come from agencies responsible for funding the CCTT system and facility. This TAQ effort should not require an intermediate quality board unless the commander wants to expand the projects to include all local training processes. The ESC should set initial goals, and establish and charter a PAT. Possible goals for an initial effort are (a) to describe the training process, (b) to develop process indicators, and (c) to identify major problems for investigation.

The PAT chair should be the supervisor of the CLS operator staff. Members should include senior AAR and SAF operators, armor and infantry unit leaders at platoon and company levels with CCTT training experience, and CCTT O/Cs with experience in platoon and company training. Various USW operators should participate when their functions are under consideration. The local TAQ office should provide a trained facilitator.

Identifying Problems

The PAT should begin by preparing a series of flowcharts (Walton, 1986; GOAL/QPC, 1988) showing the actual step-by-step sequence of actions and decisions that complete phases of the training process. Branches show alternatives when ways of performing a process segment vary. The PAT should compare these charts to the "ideal" process designed by the TSP developers (STRUCCTT Team, 1997) to find differences. Examination of the differences must determine if they are possible problem sources, or process improvements. The PAT looks for gaps, loops, conflicts, or complexities that may lead to process mistakes, breakdowns, delays, inefficiencies, and variation. Brainstorming, multi-voting, or nominal group techniques (Sholtes, 1988) may be used to nominate, select, and set priorities for further work.

Further detail on the allocation of responsibilities may be described by deployment charts (Sholtes, 1988) that show "suppliers" providing input and "customers" receiving output of each step, and "owners" who perform each step. These charts identify who must make any needed changes in the process.

The PAT should also perform cause-effect analysis (Sholtes, 1988; GOAL/QPC, 1988) on process stages or functions. This method focuses on the result or outcome, defining desired and undesired characteristics for the output of a stage or function. Examining the flowchart, the PAT seeks to trace back to root causes all factors that influence the output. A causal tree diagram (the Ishikawa "fishbone" diagram in Figure 2) is used to record the analysis with causal

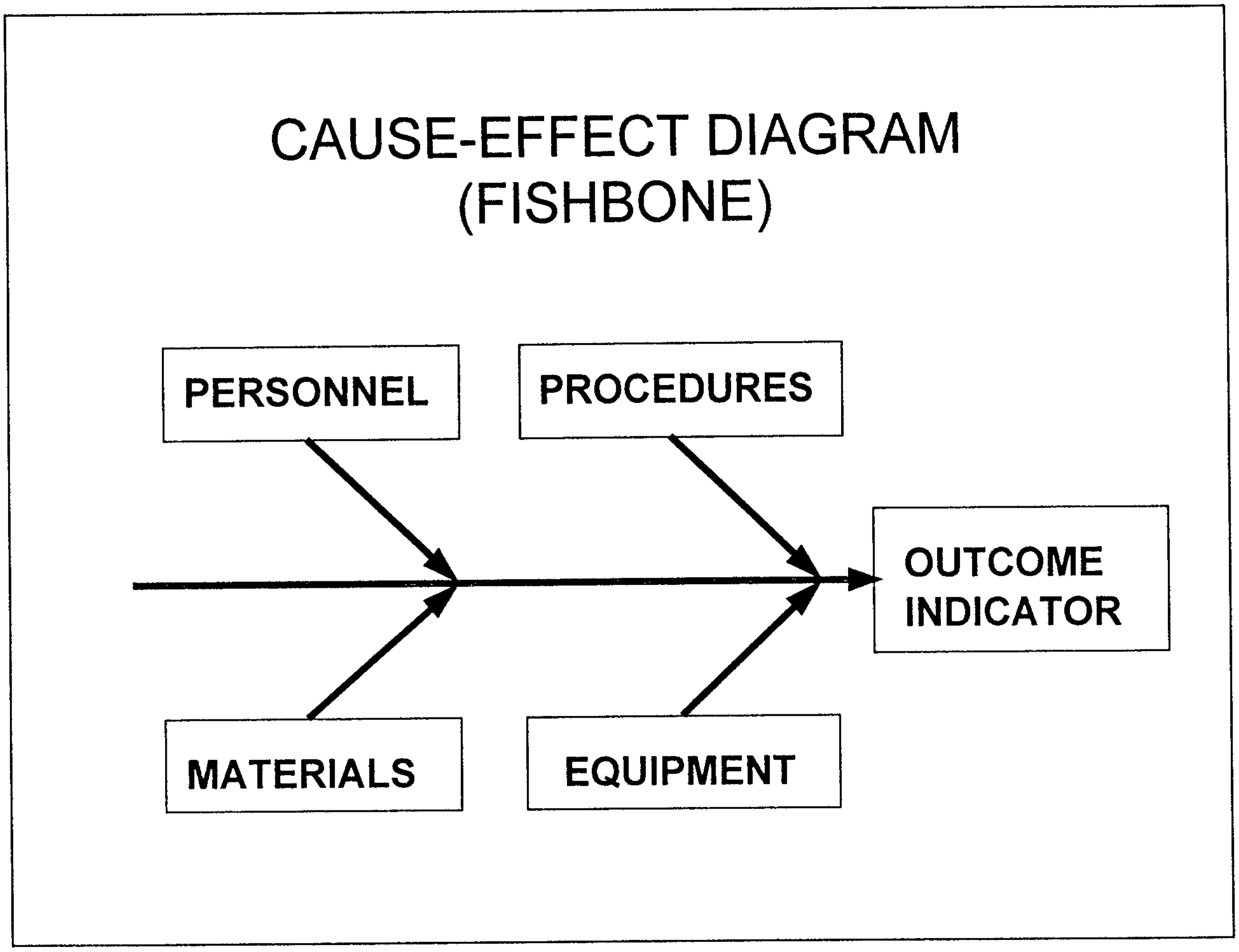

Figure 2. Tree diagram with major causal categories.

chains drawn as leaves and branches from main limbs showing major categories of causes. These diagrams identify aspects of the process providing concepts for measurement.

Developing Quality Indicators

For parts of the process selected for priority attention, the PAT must develop measures to assess how the sub-process is working in the current system. In addition, they should develop criteria of quality for the product or output of the total process. The flow charts and cause-effect diagrams lay out a myriad of possible concepts for measurement. The PAT selects indicators that have the greatest impact on the ultimate criteria of quality, that are relatively objective, and that are feasible and not too costly. Advice from an experienced quality management consultant may be useful in selecting indicators and setting up an efficient data collection system. A later section of this report presents some candidate indicators for CCTT structured training.

Indicators must be operationally defined to specify who must observe and record what events or variables, at what locations, and under what circumstances. Definitions must include the units and scales of measurement for each indicator. Checklists, forms, and surveys organize the selected measures for data collection. A detailed plan should specify the data collection process and procedures for reproducing, distributing, collecting, and processing completed forms. Some clerical staff may be required to monitor data collection, audit records, and manage databases. Data collection must be integrated with other activities to avoid interfering with the process under observation, to reduce the data recording burden combined with training duties, and to minimize added costs for site operation.

All personnel involved in the CCTT training process will contribute data under some circumstances. Site managers can report administrative data. Unit leaders and O/Cs can supply information on pre- and post-exercise activities by using checklists provided with the Unit Training Guide and Post-Exercise Report forms. Units can fill out customer satisfaction surveys before and after on-site training. The O/C, AAR and SAF operators, and USW operators can provide training data using the event guide, data-entry windows added to workstations, and post-exercise forms. Operators can accumulate automated performance data records from the CCTT system. The ICW computers also can collect automated data from EDUCATT training.

Monitoring Processes

Collection of indicator data should continue over a long time for all units using the CCTT TSPs. Data analysis should use standard graphic methods that have proven their value in quality projects. For example, Pareto charts show ordered relative frequencies of categories to highlight the most important problems or causes identified in a set of alternatives.

Control charts with qualitative or quantitative data show process stability or trends over time. Such charts also show how much variation normally occurs in process measures. Control charts help to identify changes, and extreme values traceable to some "special" cause (Deming, 1986). Early improvement efforts seek to prevent trends and special causes, leading to a stable process with variation resulting only from "common" causes inherent in the process. A stable process establishes a baseline for evaluating the effect of planned process improvements.

Stratification (Sholtes, 1988), regression, and structural equation analyses also can be used to examine hypotheses about cause-effect relationships contributing to common variation. Many commercial and statistical software packages are available to do these analyses.

Developing Changes

As the PAT identifies problems, it should focus first on changes producing short-term, big wins to increase the impetus for TAQ management projects. Sholtes (1988) presents 11 strategies for change, but the basic approach remains constant. The PAT must define the reason for change and the goal to be met in terms of measurable criteria, then design alternatives and examine their advantages and disadvantages. Changes also must meet situational constraints and avoid unintended consequences. The PAT must plan changes, have them approved by the ESC, and give training to those affected. The organization then tries out the change (e.g., with a sample of units) and evaluates the results by the defined criteria. The PAT may then accept the change as meeting the goal or they may modify it and try again.

Adopting Changes

The PAT needs to supervise the installation of permanent changes, and then monitor their effects to confirm that the results continue. Minor problems or by-products may emerge, and the change may have to be refined and standardized. The change will also require associated changes in training for all affected positions. The PAT should document and publicize the long-run impacts of improvements in terms of savings, return on investment, or cost/benefit ratios.

Central Authority

Certain problems and solutions transcend the local installation and CCTT site. Changes or innovations in procedures or TSPs required by hardware and software upgrades, or new equipment and doctrine, apply to all sites. Some central agency must have authority to coordinate and disseminate common changes across sites. Such an agency would be responsible for collecting and distributing the best quality improvements developed at local sites. To flesh out the standard TSP library, all sites could provide modified or new TSPs developed by local units that prove to be generally useful. This agency also would identify unmet training needs, and define requirements for hardware and software upgrades and additions.

Quality Indicators

Our experience with the VTP (Shlechter, Bessemer, Nesselroade, & Anthony,1995; Shlechter, Kraemer, Bessemer, & Burnside, 1996) and the formative evaluation of the CCTT TSPs has developed an appreciation for some events and conditions that contribute to successful training. Process indicators like those shown in Table 2 may be valuable for monitoring some aspects of CCTT training. However, more detailed conceptual analysis is needed to define measures of operational performance for the total training system that can be accepted as direct indices of training quality. Designs for future TSPs should include data collection procedures for indicators that support quality management methods. For example, the O/C could provide salient facts about exercise execution by filling out a brief form provided with each Exercise Guide.

Supporting Tools

Future simulation developments should consider requirements for data collection and analysis that support quality management. Current acquisition policy for training devices does not contemplate such requirements, nor does it consider data collection to be part of contractor logistic support. Responsible agencies should make necessary changes in both philosophy and regulation to enable better long-term management of simulation-based training.

Commercial off-the-shelf (COTS) software can meet most needs, but this software should be integrated and interactive with the simulator system. The CCTT site needs other tools to support information distribution, scheduling, coordination, and collection of administrative data. For example, an Internet Web site could be set up to provide efficient user access and interaction with the CCTT site for remote ARNG or Reserve units.

Table 2

Quality Indicators in Training Phases

Pre-Exercise Phase • Unit training needs and exercises selected. • Lead times completing unit schedule. • Lead times to identify O/C and USW operators. • Lead times for distribution of training guides. • Unit leaders' time spent studying guidance. • O/C and USW operators' time studying guidance. • Times used in troop leading and rehearsals. **Preparation Phase** • Time used in ICW training. • Time used in unit's Familiarization Exercise. • Attendance in the Familiarization Exercise. • Time used in the Practical Exercise • Personnel participating in the Practical Exercise **Exercise Training Phase** • Number of exercises and proportion repeated. • Total unit on-site time and training time. • Time to complete preview, execution, and AAR. • Quality and completeness of leader's brief back. • Time and distance traveled in leader's reconnaissance.	• Proportion of planned exercise tasks occurring. • Coaching or other Event Guide variations required. • Proportion of trained tasks discussed in AAR. • Proportion of unit participating in the AAR discussion. • Delays waiting for visual or radio replays. • Attendance in preview, execution, and AAR. • Personnel turnover across exercises. **Post-Exercise Phase** • Time spent in report preparation by the O/C. • Interval between training and report delivery. • Who saw and used the report in the unit. • Unit training done in the next quarter. **Outcome Measures** • Gain in performance between first and later performance of repeated tasks and sub-tasks. • Gain in unit and leader proficiency rated before and after training by participants and the O/C. • Effect on performance in initial field exercises compared to untrained baseline or control units. • User satisfaction with training site services.

For quality management, the simulator system should provide flexible tools for on-line observer or operator data entry. Computers with database, statistics, and process control software should network with the simulator system to download indicator data, and network with office computers to feed preparation of presentations and reports. Proper equipment can simplify survey data entry. Multi-media editing capabilities may enable advanced graphic analysis methods more tactically revealing than the statistical methods now used, as well as contributing to more vivid, effective AARs and Post-Exercise reports.

Wilkinson (1997) identified several types of tools needed to aid commanders and staff to make the best possible use of the CCTT. One should provide an informative overview of CCTT and a means of exploring in greater depth the capabilities and limitations of the CCTT in relation to doctrine and tactics, techniques, and procedures. This tool would provide the unit guidance on what training to conduct in CCTT in preference to other alternatives. A second tool would provide software support for retrieving existing exercises and TSP materials and modifying them, or developing new exercises and materials as needed to meet the unit's training needs. A third tool would assist the user to set up and check out the workability of the data input files and system initialization files required for executing a planned CCTT exercise. All of these functions are to be provided by software in the "Commander's Integrated Training Tool" being developed to support user's preparation for unit training with CCTT (U.S. Army Research Institute for the Behavioral and Social Sciences, 1997).

Conclusion

This report advanced the hypothesis that the U.S. Army TAQ program can serve as a workable model of management oversight for sustaining and improving simulator-based training. Managers and trainers should test this hypothesis with the CCTT and other existing simulator systems and training programs. If the results prove beneficial, acquisition requirements for new training simulators should provide support for quality management mechanisms. Long-term management functions and tools have been neglected in the current DIS standard for Exercise Management and Feedback, and deserve consideration when the standard is revised or expanded. As new standards for HLA are developed, the FEDEP should include the sustainment and improvement of training applications.

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